

FISHERIES RESEARCH INSTITUTE
SCHOOL OF FISHERIES, BOX 357980
UNIVERSITY OF WASHINGTON
SEATTLE, WASHINGTON 98195

**FISH ASSEMBLAGES AND JUVENILE SALMON DIETS
AT A BREACHED-DIKE WETLAND SITE,
SPENCER ISLAND, WASHINGTON 1997-98**

J.R. CORDELL,¹ C. TANNER² AND J.K. AITKIN²

¹Wetland Ecosystem Team, Univ. Washington School of Fisheries.

²U.S. Fish & Wildlife Service

Contents

	Page
List of Figures	iv
List of Tables	iv
Introduction	1
Methods	1
Fish Sampling	1
Diet Analyses	1
Results	1
Chum Salmon Diets	2
Chinook Salmon Diets	3
Coho Salmon Diets	3
Discussion	12
References	13

List of Figures

Figure	Page
1. Location of breached-dike restoration site at Spencer Island, Washington	2
2. Spencer Island breached dike restoration site showing fish sampling locations in 1997 and 1998	3
3. Stomach fullness factor and index of percent ratio of stomach contents weight of fish weight for juvenile chum salmon captured by several methods at Spencer Island, Washington in 1997 and 1998	9
4. Percentage composition by weight of prey from juvenile chum salmon on five dates at several stations at Spencer Island, Washington, 1998	9
5. Stomach fullness factor and index of percent ratio of stomach contents weight of fish weight for juvenile chinook salmon captured by beach seine at Spencer Island, Washington in 1998	10
6. Percentage composition by weight of prey from juvenile chinook salmon on five dates at several stations at Spencer Island, Washington, 1998	10
8. Percentage composition by weight of prey from juvenile coho salmon on five dates at several stations at Spencer Island, Washington, 1998	11
7. Stomach fullness factor and index of percent ratio of stomach contents weight of fish weight for juvenile coho salmon captured by several methods at Spencer Island, Washington in 1998	11

List of Tables

Table	Page
1. Tides and fish sampling periods for 1998 south Spencer Island sampling	4
2. Summary of 1998 south Spencer Island fish abundance data	5
3. All fish caught and those retained for diet analyses at Spencer Island, Snohomish County in 1998	6
4. Salmonid fork lengths from 1998 south Spencer Island sampling	7

Acknowledgments

Support for this research was provided by the National Oceanic and Atmospheric Administration Coastal Zone Management Program, Washington Department of Ecology, and the U.S. Fish and Wildlife Service Puget Sound Program. We would like to thank Ayesha Gray, Andy Haas, Steve Hager, James Kim, Dave Low, Kate O'Keefe, Eric Reeder, Paul Renaud, Lucinda Tear, and Jason Toft for helping with fieldwork.

Key Words

fish assemblages, juvenile salmon diet, Snohomish River estuary, wetland restoration

FISH ASSEMBLAGES AND JUVENILE SALMON DIETS AT A BREACHED-DIKE WETLAND SITE, SPENCER ISLAND, WASHINGTON 1997-98

J.R. CORDELL, C. TANNER, J.K. AITKIN

Introduction

In 1997 we studied the biological status of a breached-dike restored wetland site on South Spencer Island, which is located in the Snohomish River estuary near the city of Everett, Washington (Fig. 1, Cordell et al. 1998). One of the components of this study was sampling fish presence and salmonid diets at the site. Fish were captured with small gillnets in several habitats, a fyke trap in a main drainage channel, and on one date, a small two-person pole seine (see Cordell et al. 1998 for descriptions of sampling sites and gear). Because these techniques proved relatively unsuccessful, we sampled fish at Spencer Island beginning in April 1998 using beach seines. The purpose of this report is to present the 1998 fish sampling and diet results and compare these results to data from the 1997 fish collections.

Methods

Sampling Sites

We chose three areas for sampling fish at the South Spencer Island restoration site (Fig. 2). The first was located just inside the primary breach connecting the restoration site with Union Slough. The other two areas were located on a mudflat adjacent to the cross levee that separates the restoration site from managed waterfowl habitat: the west mudflat site abutted an extensive *Typha* and *Phalaris arundinacea* marsh that dominates the restoration site.

Fish Sampling

We sampled the south Spencer Island restoration site approximately every 2 weeks from 3 April to 12 June 1998 for a total of six sampling periods (Table 1). Samples were taken with a 37-m floating beach seine. The net consisted of two 18-m panels made of 3-cm mesh with a 2-m x 2.4-m x 2.3-m bag made of 6-mm mesh. Sets were made within 1 hour of high tide to maximize the amount of water over the sites. The net was deployed from a small inflatable boat parallel to shore and was pulled in by two 2-person teams.

Captured fish were anesthetized in a plastic bucket in

which water with a small amount of MS-222 (tricaine) had been added. All fish were then identified to species and counted. Salmonids were measured (fork length) and a subsample of 10 salmon from each 10-mm size class was preserved immediately in a 10% formaldehyde solution. All other fish were placed in freshwater until they recovered, and then were released.

Diet Analyses

In the laboratory, individual fish were measured (fork length) and weighed damp (excess water was blotted off with tissue) to the nearest 0.01 g. Stomachs were removed and opened, and each stomach was assigned a fullness rank (1 = empty, 6 = full) and digestion rank (1 = no prey identifiable, 6 = all prey identifiable). The contents were then weighed damp in their entirety, placed on a plastic petri dish, and separated into individual taxa under a dissecting microscope. Prey were identified to species level for crustaceans and to family level for insects. Each taxon was enumerated and weighed to the nearest 0.001 g. All data were entered on standard NODC (National Oceanographic Data Center) forms and analyzed using the University of Washington Fisheries Research Institute's GUTBUGS program. This program provides summary data for each group of fish analyzed; data were taken from this summary for further graphical analysis.

Results

Fish Catches

Twelve species of fish were captured during the course of this study (Table 2). Threespine stickleback (*Gasterosteus aculeatus*) dominated the overall catch (507 individuals); most of these (340) were caught in a single beach seine haul at the west mudflat site on 17 April. Peamouth chub (*Mylocheilus caurinus*) were also relatively abundant (145 individuals). Juvenile chum (*Oncorhynchus keta*) (174 individuals) and chinook (*O. tshawytscha*) (148 individuals) salmon were the most abundant salmonids (Tables 3, 4). Coho salmon (*O. kisutch*) were the third most numer-

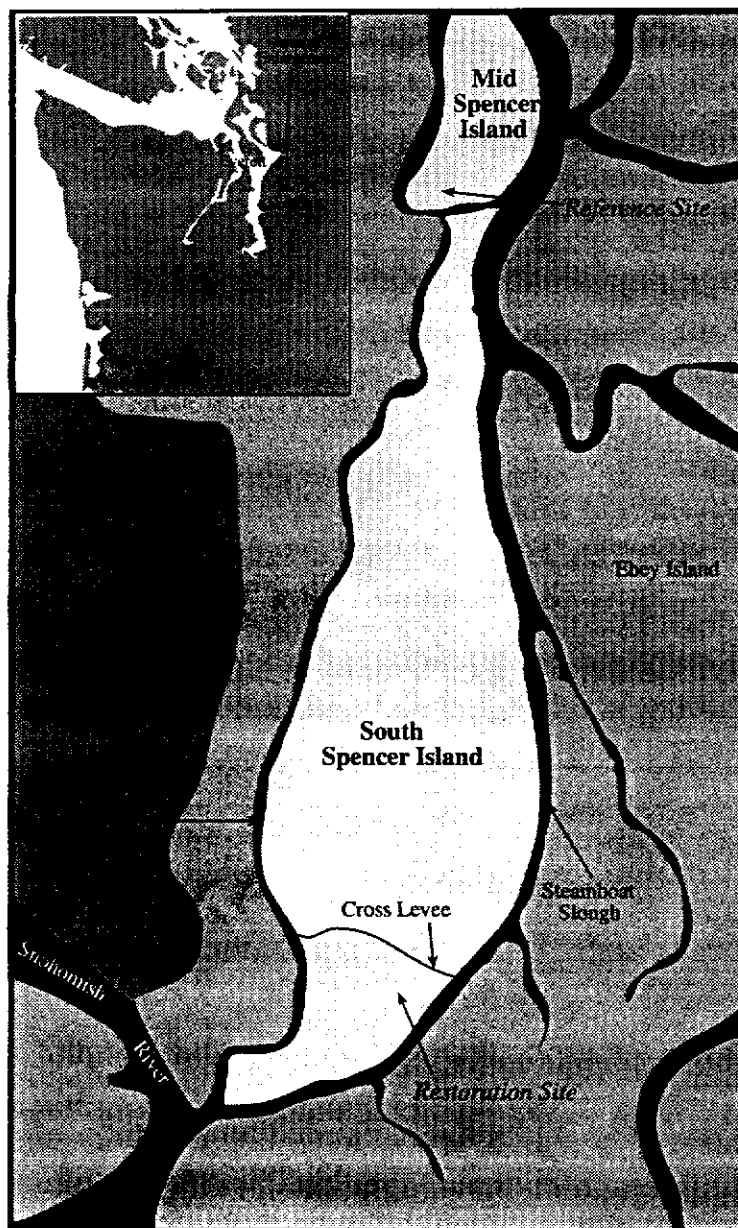


FIGURE 1. Location of breached-dike restoration site at Spencer Island, Washington.

ous salmon species (59 individuals). Overall catches of other salmonids were small, consisting of 15 pink salmon (*O. gorbuscha*), one steelhead trout (*O. mykiss*), and one cutthroat trout (*O. clarki*). Numbers of fish caught per date were relatively consistent across the sampling period for chum and chinook salmon and for peamouth chub (Table 2). Coho salmon were relatively abundant only on the two May sample dates.

Chum Salmon Diets

A total of 68 juvenile chum salmon were analyzed for diet composition. Stomach fullness and instantaneous ra-

tion (the percent ratio of stomach contents weight to fish weight) were similar throughout the 1998 study period, averaging 3.4 and 1.32, respectively (Fig. 3). These values were lower in 1998 than in 1997.

Larvae and pupae of chironomid flies dominated the prey weight in juvenile chum salmon at every site and date analyzed except for two individuals from the 29 May sample taken near the large dike breach (Fig. 4). Prey in these fish consisted of adult dipteran flies, ceratopogonids, and larval fish. Diet from juvenile chum salmon captured at the two mudflat sites was especially dominated by chironomids, which constituted about 80% of prey weight.

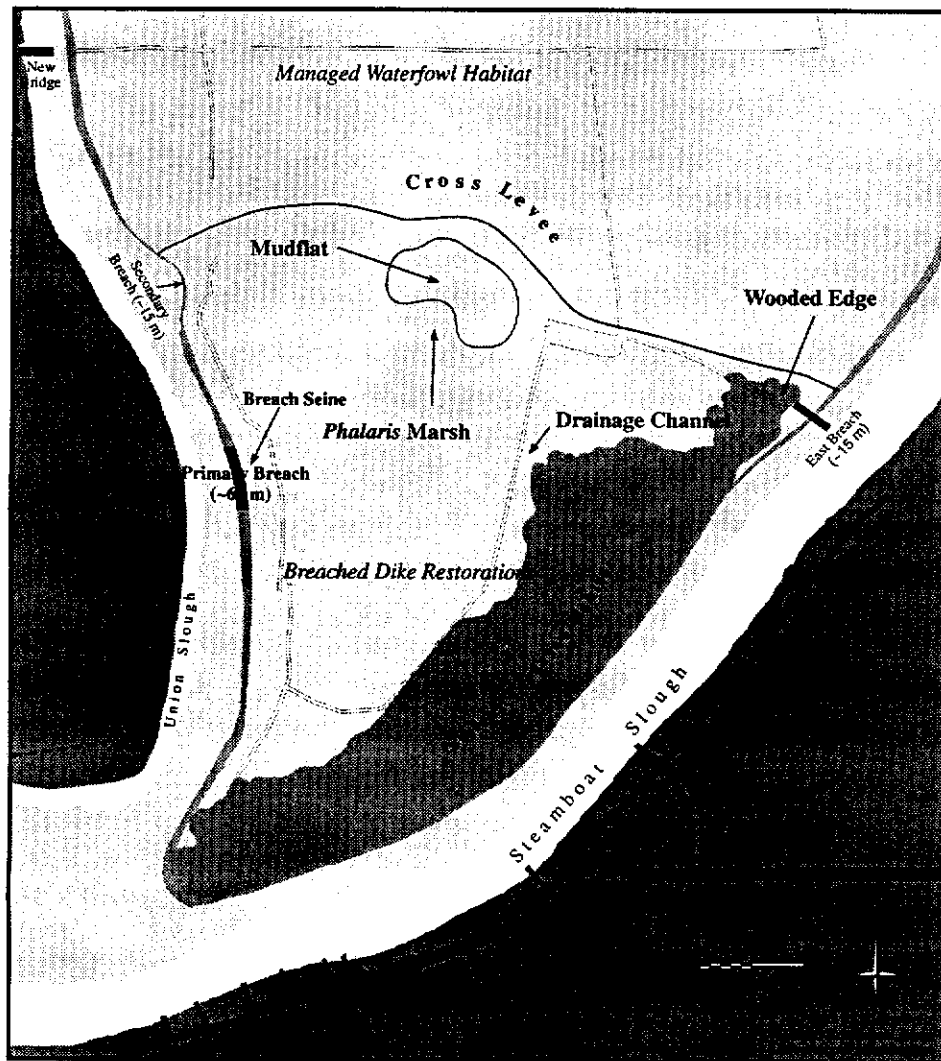


FIGURE 2. Spencer Island breached dike restoration site showing fish sampling locations in 1997 and 1998.

Chinook Salmon Diets

We analyzed the diets of a total of 71 juvenile chinook salmon, all of which were caught in 1998. Stomach fullness was similar throughout the study period, with an overall average of 4.3 (Fig. 5). Instantaneous ration was somewhat more variable than for chum salmon, ranging from 0.53–1.93, with an average of 1.21.

Diet composition of juvenile chinook salmon was also more variable than for chum (Fig. 6). In early April, diet was gravimetrically dominated by the amphipods *Corophium* spp. and larval fish at the east mudflat site. In late April, chironomid fly larvae, larval fish, and *Corophium* spp. were the predominant prey taxa. From chinook captured at the mudflat sites on May sample dates, chironomid larvae and pupae dominated the diets (50–75% of prey weight). In chinook from the breach site on 15 May, prey were distributed into relatively more taxa, including the

mysid shrimp *Neomysis mercedis*, ceratopogonid fly larvae and pupae, and cercopid insects (leaf hoppers). In the 12 June sample, ceratopogonid fly larvae and pupae were dominant, constituting 83% of prey weight.

Coho Salmon Diets

We analyzed a total of 40 juvenile coho salmon stomachs taken from three sampling dates. Stomach fullness was similar throughout the 1997–98 study period, averaging 4.5 (Fig. 7). Instantaneous ration was more variable, ranging from 0.5–1.35, with an average of 0.9.

Compared with the chum and chinook salmon diets, which consisted mainly of chironomids and larval fish, prey weight in coho salmon was dominated by crustaceans (Fig. 8). One or two crustacean taxa dominated the diet at each site and date: *Neomysis mercedis* at the breach site on 17 April; *Corophium* spp. at both mudflat sites on 15

Text continues on p. 12

TABLE 1. Tides and fish sampling periods for 1998 south Spencer Island sampling.

Date	Everett tides			Beach seine (30 m)				Notes	
	low time	low feet	high time	high feet	east mudflat		west mudflat		Crew A
					start	end	start	end	
3-Apr	3:49	6.1	9:05	9.5	16:10	0.4	10:30	11:30	KA, JC, AH, LT & AG
					9:30	10:30	1:00	8:30	
17-Apr	3:19	6.1	8:19	9.3	15:25	0.2	9:30	9:50	KA, JC, CT, AG & KO
					8:45	9:15	0:30	10:30	
1-May	3:33	6.0	8:35	9.4	15:34	-0.5	9:40	10:05	KA, JC, CT & JT
					9:00	9:30	0:30	11:00	
15-May	2:17	6.3	7:03	9.5	14:11	-1.0	7:30	8:10	KA, JC, AG & DL
					7:30	7:45	0:15	8:45	
29-May	2:22	6.1	7:14	9.7	14:15	-1.6	7:30	8:30	KA, JC, SH & JK
					7:30	7:45	0:15	8:45	
12-Jun	1:15	6.6	5:56	9.8	13:07	-1.8	7:35	8:30	JC, CT, PR & ER
					7:35	7:50	0:15	9:10	
								9:25	
								0:15	

^ACrews consisted of Kevin Aitkin (KA), Jeff Cordell (JC), Ayesha Gray (AG), Andy Haas (AH), Steve Hager (SH), James Kim (JK), Dave Low (DL), Kate O'Keefe (KO), Eric Reeder (ER), Paul Renaud (PR), Curtis Tanner (CT), Lucinda Tear (LT), Jason Toft (JT).

Two hauls were made at the breach site, but no fish were captured.

Two hauls were made at the breach site, but fish were captured only on the first haul.

TABLE 3. All fish caught (top) and those retained for diet analyses (bottom) at Spencer Island, Snohomish County in 1998.

Date	Chum	Pink	Chinook	Coho	Steel-head	Cut-throat	Threespine stickleback	Peamouth chub	Bluegill /						Prickly sculpin	Sculpin spp.	Starry flounder	Frog spp.
									ed	pumpkinse	Staghorn sculpin							
3-Apr	22	6	26	0	0	0	8	0	0	0	0	0	0	0	0	0	0	
17-Apr	86	7	29	2	0	0	344	15	1	2	0	0	0	0	0	0	0	
1-May	37	0	15	0	1	0	113	37	1	0	0	0	0	0	2	1	1	
15-May	26	2	25	38	0	0	10	43	0	0	0	0	0	0	1	0	0	
29-May	3	0	19	17	0	1	25	28	0	0	0	1	0	0	0	0	0	
12-Jun	0	0	34	2	0	0	7	22	1	0	0	0	13	2	2	0	0	
TOTAL	174	15	148	59	1	1	507	145	3	2	1	1	13	5	5	1	1	

Date	Chum	Pink	Chinook	Coho	Bluegill /	
					Pumpkinseed	Pumpkinseed
3-Apr	13	6	12	0	0	0
17-Apr	35	7	18	2	0	0
1-May	20	0	10	0	1	1
15-May	15	1	24	17	0	0
29-May	3	0	19	17	0	0
12-Jun	0	0	34	2	0	0
TOTAL	86	14	117	38	1	1

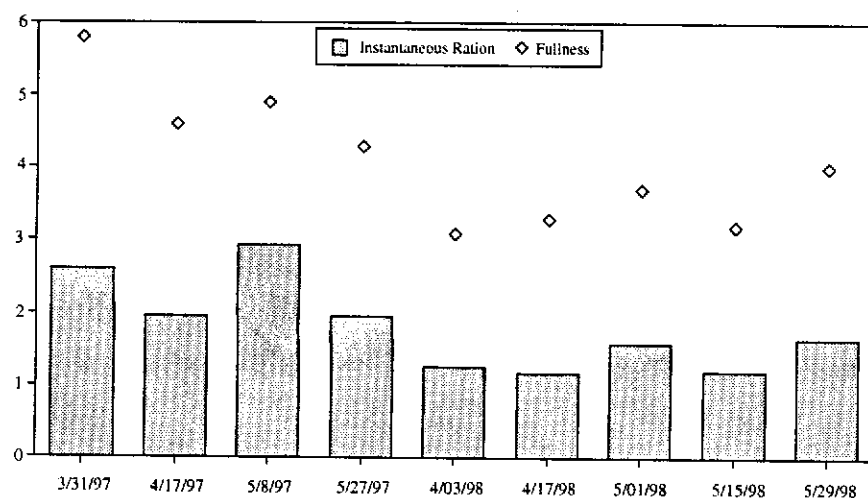


FIGURE 3. Stomach fullness factor (1 = empty, 6 = full) and index of percent ratio of stomach contents weight of fish weight for juvenile chum salmon captured by several methods at Spencer Island, Washington in 1997 and 1998. Vertical lines represent standard deviations.

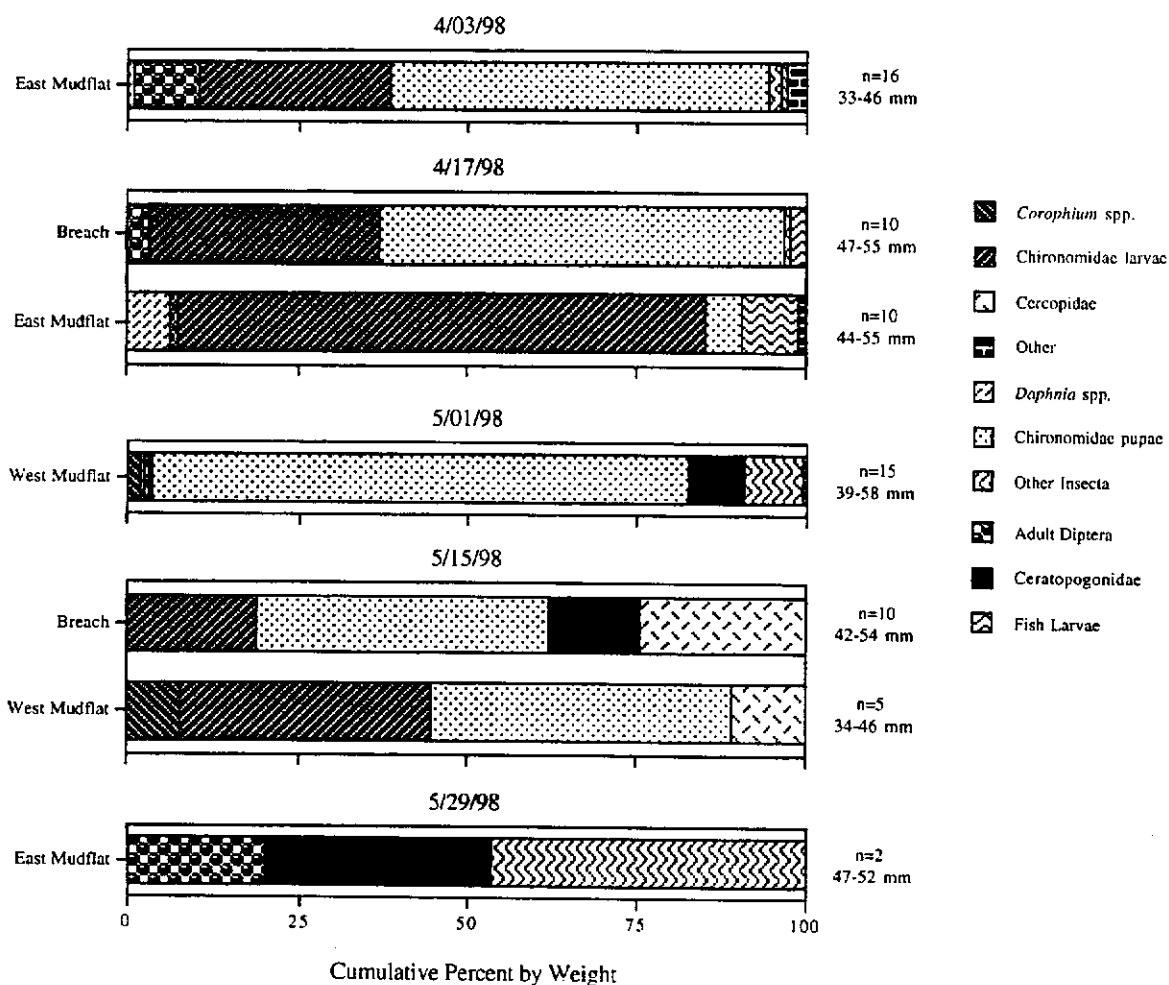


FIGURE 4. Percentage composition by weight of prey from juvenile chum salmon on five dates at several stations at Spencer Island, Washington, 1998.

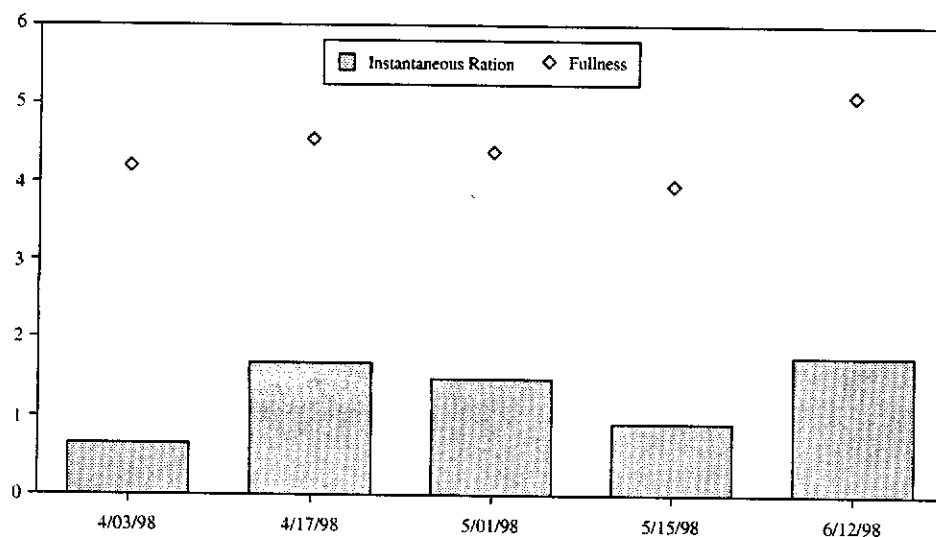


FIGURE 5. Stomach fullness factor (1 = empty, 6 = full) and index of percent ratio of stomach contents weight of fish weight for juvenile chinook salmon captured by beach seine at Spencer Island, Washington in 1998. Vertical lines represent standard deviations.

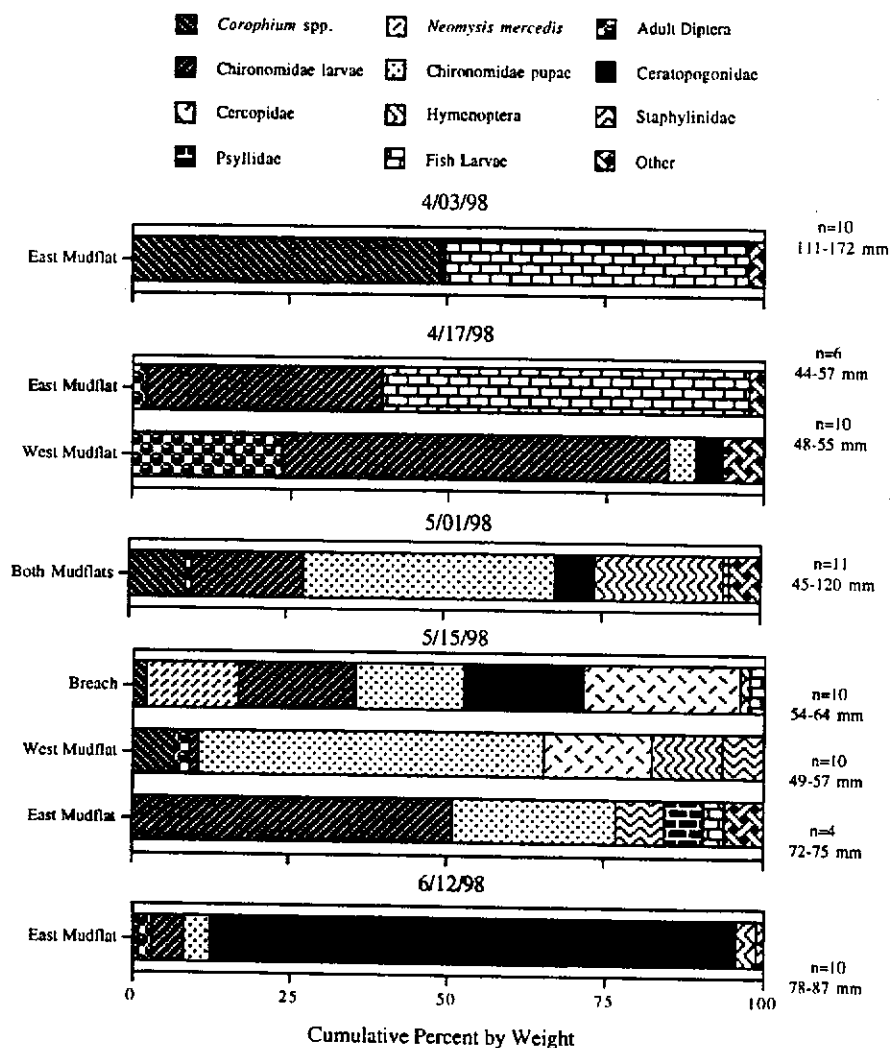


FIGURE 6. Percentage composition by weight of prey from juvenile chinook salmon on five dates at several stations at Spencer Island, Washington, 1998.

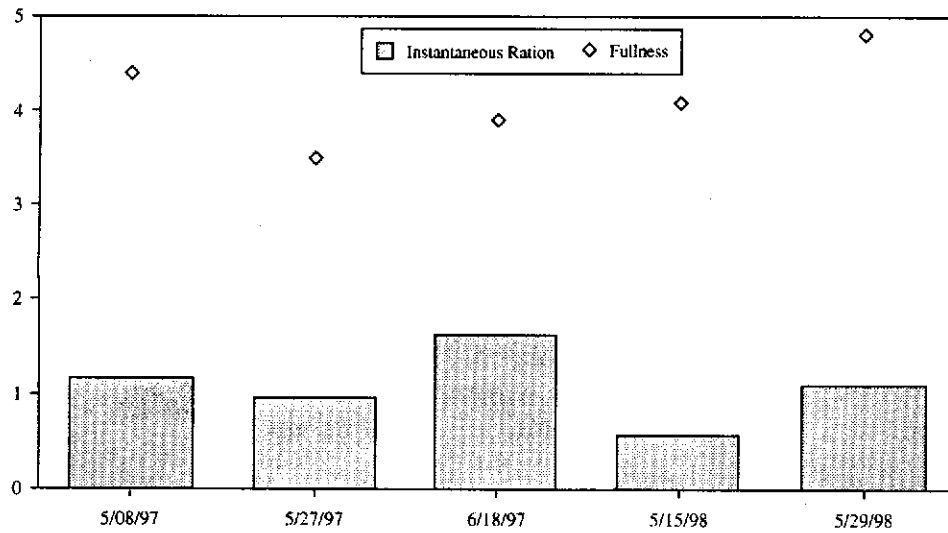


FIGURE 7. Stomach fullness factor (1 = empty, 6 = full) and index of percent ratio of stomach contents weight of fish weight for juvenile coho salmon captured by several methods at Spencer Island, Washington in 1998. Vertical lines represent standard deviations.

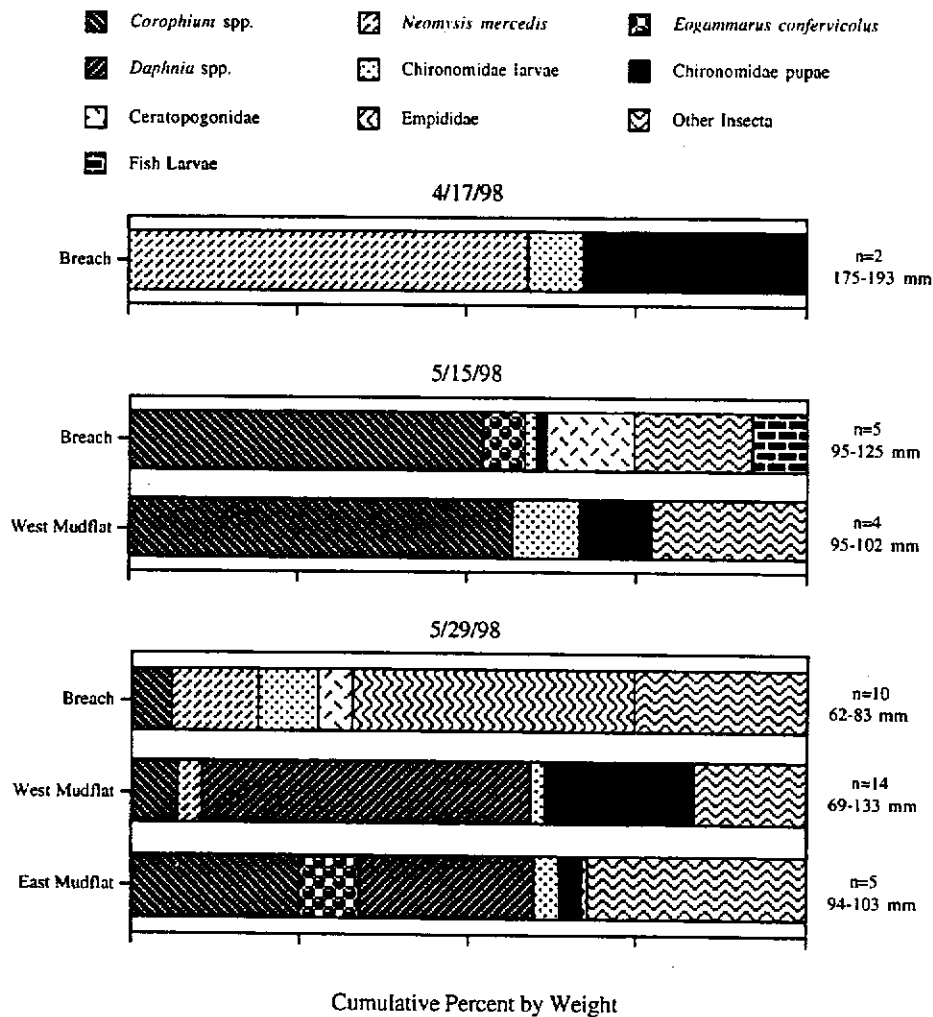


FIGURE 8. Percentage composition by weight of prey from juvenile coho salmon on five dates at several stations at Spencer Island, Washington, 1998.

May; and *Corophium* spp., the gammarid amphipod *Eogammarus confervicolus*, and *Daphnia* spp. cladocerans at the mudflat sites on 29 May. Insects dominated coho diets only at the breach site on 29 May, in which case prey consisted of mostly empidid fly larvae and a variety of other insects.

Discussion

In 1998 we caught almost five times as many salmonids as were caught in 1997, and five additional fish species on the same number of sampling dates. In addition, we caught 148 chinook salmon in 1998 and none in 1997. This difference may be due to between-year differences in amounts and patterns of use by juvenile salmon at the site. However, we believe that increased catches in 1998 were due to better catches by the 37-m beach seine compared with the gillnets and channel traps previously used (see Cordell et al. 1998 for a discussion of the problems using these gear types). Our 1998 catches were also much more consistent than in 1997, when nearly half of the juvenile salmon were caught in a single, small two-person pole seine sample on one date (Cordell et al. 1998). The consistency of our catches of chum and chinook salmon across the sampling period in the interior regions of the site suggests that these species regularly access the breached-dike restoration site.

With respect to the predominance of chironomid flies, the diets of chum salmon captured at the restoration site in 1998 were similar to those in 1997. This dominance by chironomids is similar to results from diet analyses of chum salmon from other estuarine sites (Congleton 1978, Northcote et al. 1979, Shreffler et al. 1992, Cordell et al. 1997), including freshwater tidal creeks in the Fraser river estuary (Levings et al. 1995). This finding is not surprising; given the dominance of that taxon in the benthic core and fallout trap samples collected at Spencer Island in 1997 (Cordell et al. 1998) and in emergence traps from marsh habitats in the Fraser river estuary (Whitehouse et al. 1993). As in diets from chum salmon sampled at Spencer Island in 1997, crustaceans such as harpacticoid copepods represented only a minor percentage of prey weight. This result differed from earlier studies in the lower Fraser and Nanaimo river estuaries, in which harpacticoid copepods and other crustaceans were relatively important prey items (Levy and Northcote 1981, Levings and Nishimura 1997, Sibert et al. 1997). The scarcity of harpacticoid copepods in chum salmon diets from Spencer Island may be due to the lack of harpacticoid prey of sufficient size at this site. For example, typical chum salmon harpacticoid prey species are rare in similar habitats in the Chehalis and Puyallup river estuaries (Shreffler et al. 1990; Thom et al. 1990, 1991; Simenstad et al. 1992, 1993, 1997), and our qualitative scans of meiofauna fractions of benthic samples taken

at Spencer Island in 1997 revealed very few harpacticoids (Cordell et al. 1998).

The diets of juvenile chinook salmon in our study, which were usually dominated by chironomids (*Corophium* spp.) and larval fish, were also very similar to diets of chinook from other restored and natural habitats in the Pacific Northwest. Shreffler et al. (1992) found that juvenile chinook residing in a restored wetland on the Puyallup River estuary were highly selective for chironomids, and Cordell et al. (1997) found that *Corophium* spp. and larval fish were prominent diet components in the Duwamish river estuary. At created and natural channels in the Chehalis river estuary, Miller and Simenstad (1997) found that chironomids and aphids were the most important prey items for juvenile chinook; chironomids were also an important prey item for chinook in tidal creeks in the Fraser river estuary (Levings et al. 1995). The above-cited studies found that aphids are rare in the diet of juvenile salmon captured in habitats that have little or no native vegetation (e.g., Duwamish, Spencer Island), but are common to abundant in the diets of fish that have been caught in habitats where such vegetation (mostly *Carex lyngbei*) is naturally occurring or replanted. As native vegetation becomes established at the Spencer Island restoration site, aphids and other plant-dependent insects may become more important prey items for juvenile chinook salmon.

Data on the feeding habits of juvenile coho salmon in tidal fresh and oligohaline reaches of estuaries are scarce, and the results of our diet analysis of 29 coho are based on one of the largest samples for this species in this habitat type. In having diets composed of insects and a relatively large proportion of benthic and epibenthic crustaceans, our results are similar to those of Miller and Simenstad (1997), who found that the mysid shrimp *Neomysis mercedis* is an important prey component at a created channel in the Chehalis river estuary. Crustaceans were also prominent in the diets of juvenile coho at Spencer Island in 1997, and in the Duwamish River estuary (Cordell et al. 1997, 1998). The isopod *Asellus* (= *Caecidotea*) was prominent in the diets of a small sample of coho presmolts from tidal creeks in the Fraser river estuary (Levings et al. 1995) and from the coho captured at Spencer Island in 1997 (Cordell et al. 1998).

Because the breaches at the Spencer Island restoration site were open during our sampling, we cannot say definitively that the prey in the salmon stomachs were acquired on site: they may have fed in adjacent waters and entered the site just before capture. However, we attempted to control for this by sampling near high slack tide when the fish captured had presumably been inside the restoration site for the longest time. We also believe that much of the prey from salmon captured in the interior of Spencer Island had been acquired there; because the type of prey in these fish was often qualitatively different than that from fish caught

near the large breach: in particular, the channel-dwelling mysid *Neomysis mercedis* occurred almost exclusively in prey from fish caught near the breach. We found relatively high stomach fullness indices (averaging about 50–75% full) for all three species of juvenile salmon that were abundant at Spencer Island. Along with our findings from benthic and insect fallout samples taken in 1997—that the restoration site was producing juvenile salmon prey organisms in densities that equaled or exceeded those at a reference site—these results suggest that juvenile salmon are able to successfully forage at this site.

References

- Congleton, J.L. 1978. Feeding patterns of juvenile chum in the Skagit River salt marsh. Page 141-150 in C.A. Simenstad and S.J. Lipovsky (eds.), *Fish Food Habits Studies*. 1st Pacific Northwest Technical Workshop. Workshop Proceedings, Washington Sea Grant, WSG-WO-77-2. Univ. Washington, Seattle.
- Cordell, J.R., L.M. Tear, K. Jensen, and V. Luiting. 1997. Duwamish River Coastal America restoration and reference sites: results from 1996 monitoring studies. Univ. Washington School of Fisheries, Fish. Res. Inst. FRI-UW-9609. Seattle.
- Cordell, J.R., H. Higgins, C. Tanner, and J.K. Aitken. 1998. Biological status of fish and invertebrate assemblages in a breached-dike wetland site at Spencer Island, Washington. Univ. Washington School of Fisheries, Fish. Res. Inst. FRI-UW-9805. Seattle.
- Levings, C.D., D.E. Boyle, and T.R. Whitehouse. 1995. Distribution and feeding of juvenile Pacific salmon in freshwater tidal creeks of the lower Fraser River, British Columbia. *Fish. Manag. Ecol.* 2:299-308.
- Levings, C.D. and D.J.J. Nishimura. 1997. Created and restored marshes in the lower Fraser River, British Columbia: summary of their functioning as fish habitat. *Wat. Qual. Res. J. Can.* 32:599-618.
- Levy, D.A. and T.G. Northcote. 1981. The distribution and abundance of juvenile salmon in marsh habitats of the Fraser River estuary. Westwater Research Centre, Tech. Rep. 25. Univ. British Columbia, Vancouver, British Columbia.
- Miller, J.A. and C.A. Simenstad. 1997. A comparative assessment of a natural and created estuarine slough as rearing habitat for juvenile chinook and coho salmon. *Estuaries* 20(4):792-806.
- Northcote, T.G., N.T. Johnston, and K. Tsumura. 1979. Feeding relationships and food web structure of lower Fraser River fishes. Westwater Research Center Tech. Rep. 16. Univ. British Columbia, Vancouver, British Columbia.
- Shreffler, D.K., C.A. Simenstad, and R.M. Thom. 1992. Juvenile salmon foraging in a restored estuarine wetland. *Estuaries* 15:204-213.
- Shreffler, D.K., R.M. Thom, C.A. Simenstad, J.R. Cordell, and E.O. Salo. 1990. The Lincoln Avenue wetland system in the Puyallup River estuary, Washington: Phase III report; Year three monitoring, January-December 1988. Univ. Washington School of Fisheries, Fish. Res. Inst. FRI-UW-8916. Seattle.
- Sibert, J., T.J. Brown, M.C. Healey, B. Kask, and R.J. Naiman. 1977. Detritus-based food webs: exploitation by juvenile chum salmon (*Oncorhynchus keta*). *Science* 196:649-650.
- Simenstad, C.A., J.R. Cordell, J.A. Miller, W.G. Hood, and R.M. Thom. 1992. Ecological status of a created estuarine slough in the Chehalis River estuary: Assessment of created and natural estuarine sloughs, January-December 1991. Univ. Washington School of Fisheries, Fish. Res. Inst. FRI-UW-9206. Seattle.
- Simenstad, C.A., J.R. Cordell, J.A. Miller, W.G. Hood, and R.M. Thom. 1993. Ecological status of a created estuarine slough in the Chehalis River estuary: Assessment of created and natural estuarine sloughs, January-December 1992. Univ. Washington School of Fisheries, Fish. Res. Inst. FRI-UW-9305. Seattle.
- Simenstad, C.A., J.R. Cordell, W.G. Hood, B.E. Feist, and R.M. Thom. 1997. Ecological status of a created estuarine slough in the Chehalis River estuary: Assessment of created and natural estuarine sloughs, January-December 1995. Univ. Washington School of Fisheries, Fish. Res. Inst. FRI-UW-9621. Seattle.
- Thom, R.M., C.A. Simenstad, J.R. Cordell, and L.A. Hamilton. 1991. The Gog-Li-Hi-Ti wetland system in the Puyallup River estuary, Washington: Phase V report: Year five monitoring, January-December 1990. Univ. Washington School of Fisheries, Fish. Res. Inst. FRI-UW-9108. Seattle.
- Thom, R.M., C.A. Simenstad, J.R. Cordell, D. K. Shreffler, and E.O. Salo. 1990. The Lincoln Street wetland system in the Puyallup River estuary, Washington: Phase IV report; Year four monitoring, January-December 1989. Univ. Washington School of Fisheries, Fish. Res. Inst. FRI-UW-9004. Seattle.
- Whitehouse, T.R., C.D. Levings, and J.S. MacDonald. 1993. Chironomid (Diptera) insects from natural and transplanted estuarine marshes in British Columbia. Pages 499-524 in *Proceedings of the 1993 Canadian Coastal Conference* May 4-7, 1993, Vancouver, British Columbia. Coastal Zone Engineering Program of the National Research Council, Ottawa.